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(54) **MULTI-LAYER PRINTED CIRCUIT BOARD AND METHOD FOR MANUFACTURING THE SAME**

(75) Inventors: **Toshikazu Harada**, Kariya (JP); **Koji Kondo**, Toyohashi (JP)

(73) Assignee: **Denso Corporation**, Kariya (JP)

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(51) **Int. Cl.**
H05K 1/03 (2006.01)

(52) **U.S. Cl.** **174/255**; 361/794

(58) **Field of Classification Search** 174/255, 174/262, 260, 258; 361/792, 793, 794, 795

See application file for complete search history.

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Primary Examiner—K. Cuneo
Assistant Examiner—Ishwar I. B. Patel
(74) *Attorney, Agent, or Firm*—Posz Law Group, PLC

(57) **ABSTRACT**

A multi-layer printed circuit board includes an insulation substrate; a surface conductive pattern disposed on a surface of the insulation substrate; and an inner conductive pattern embedded in the insulation substrate. The surface conductive pattern has a surface roughness on an insulation substrate side, the surface roughness of the surface conductive pattern being larger than that of the inner conductive pattern.

7 Claims, 4 Drawing Sheets

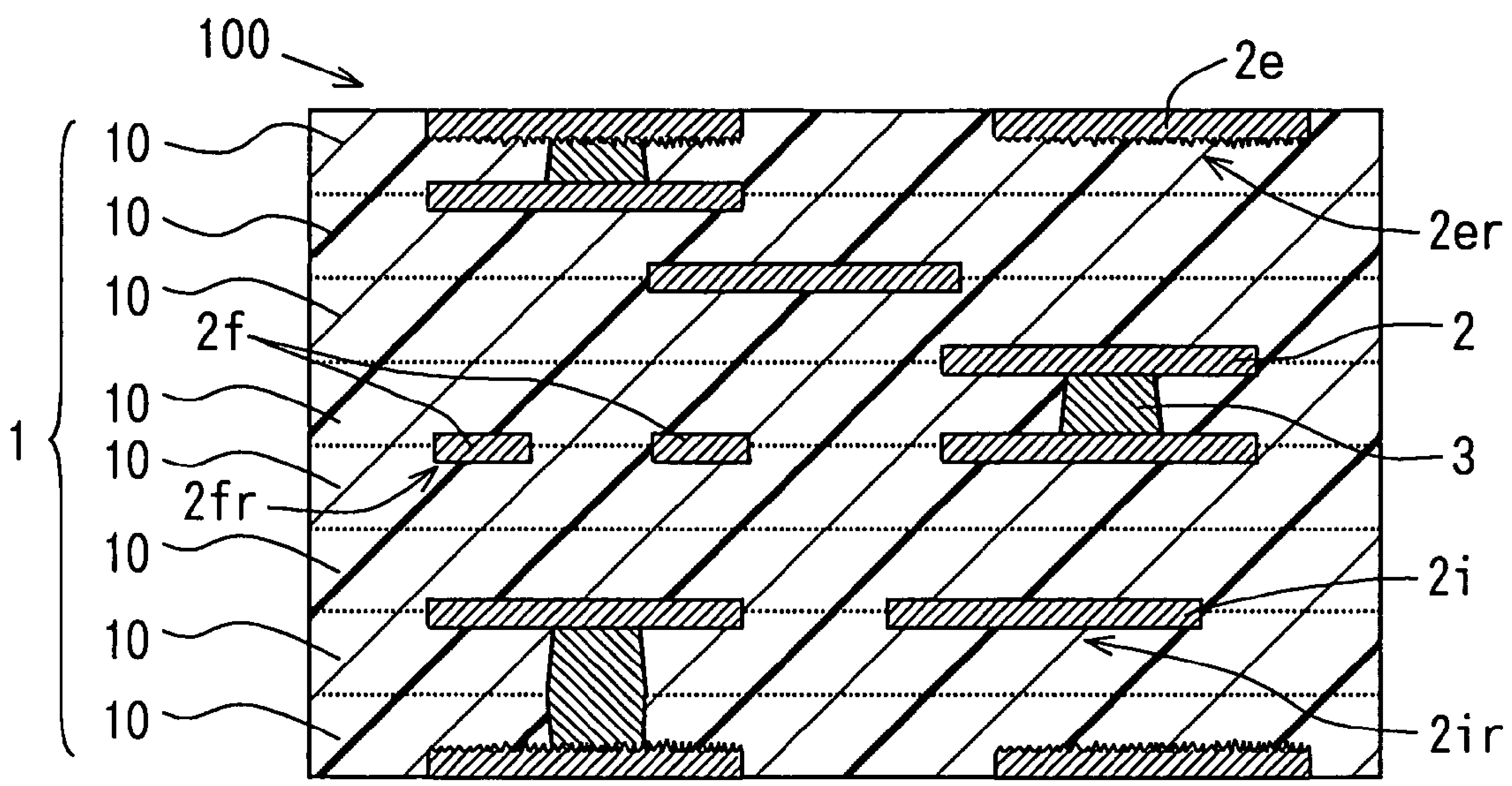

FIG. 1A

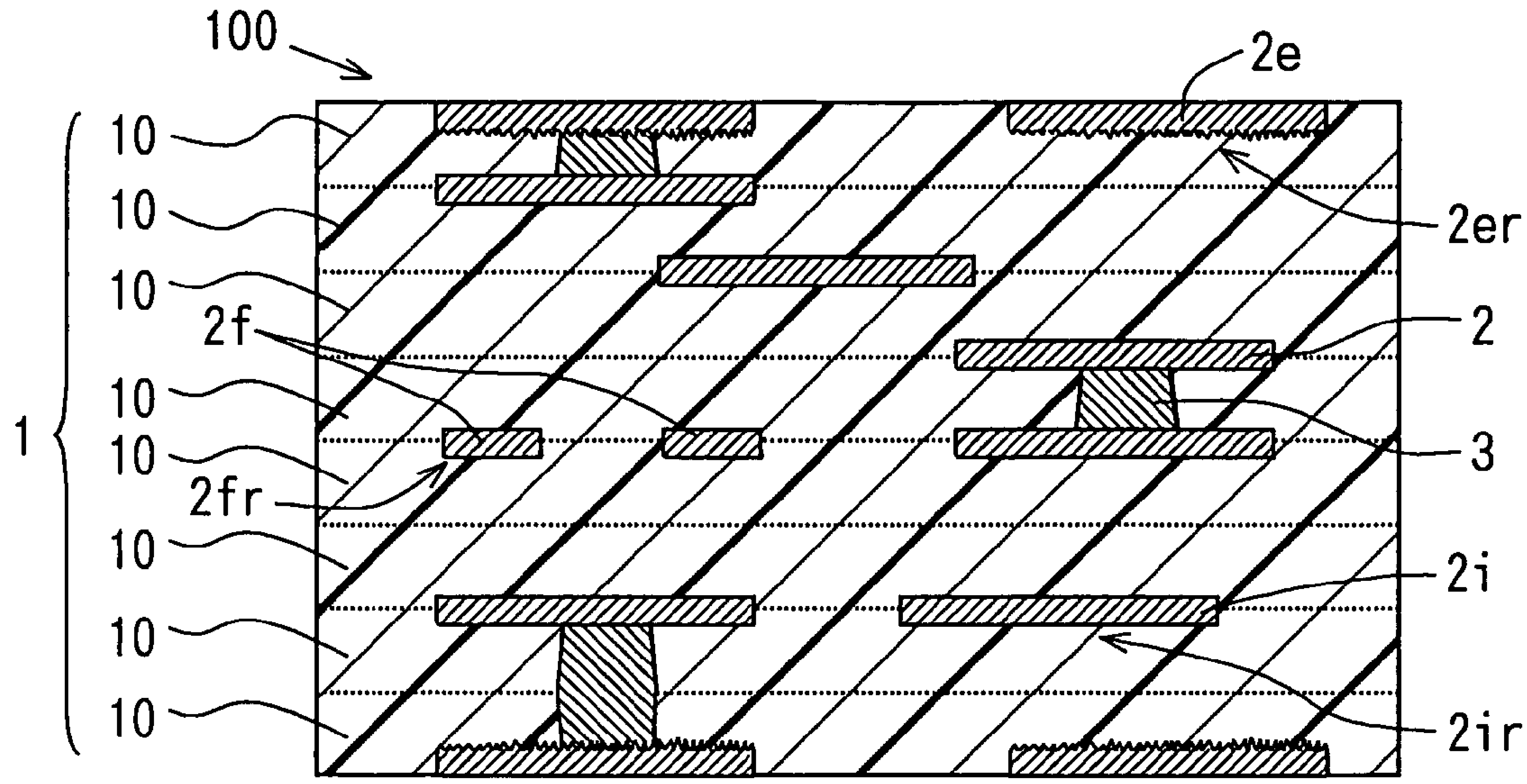
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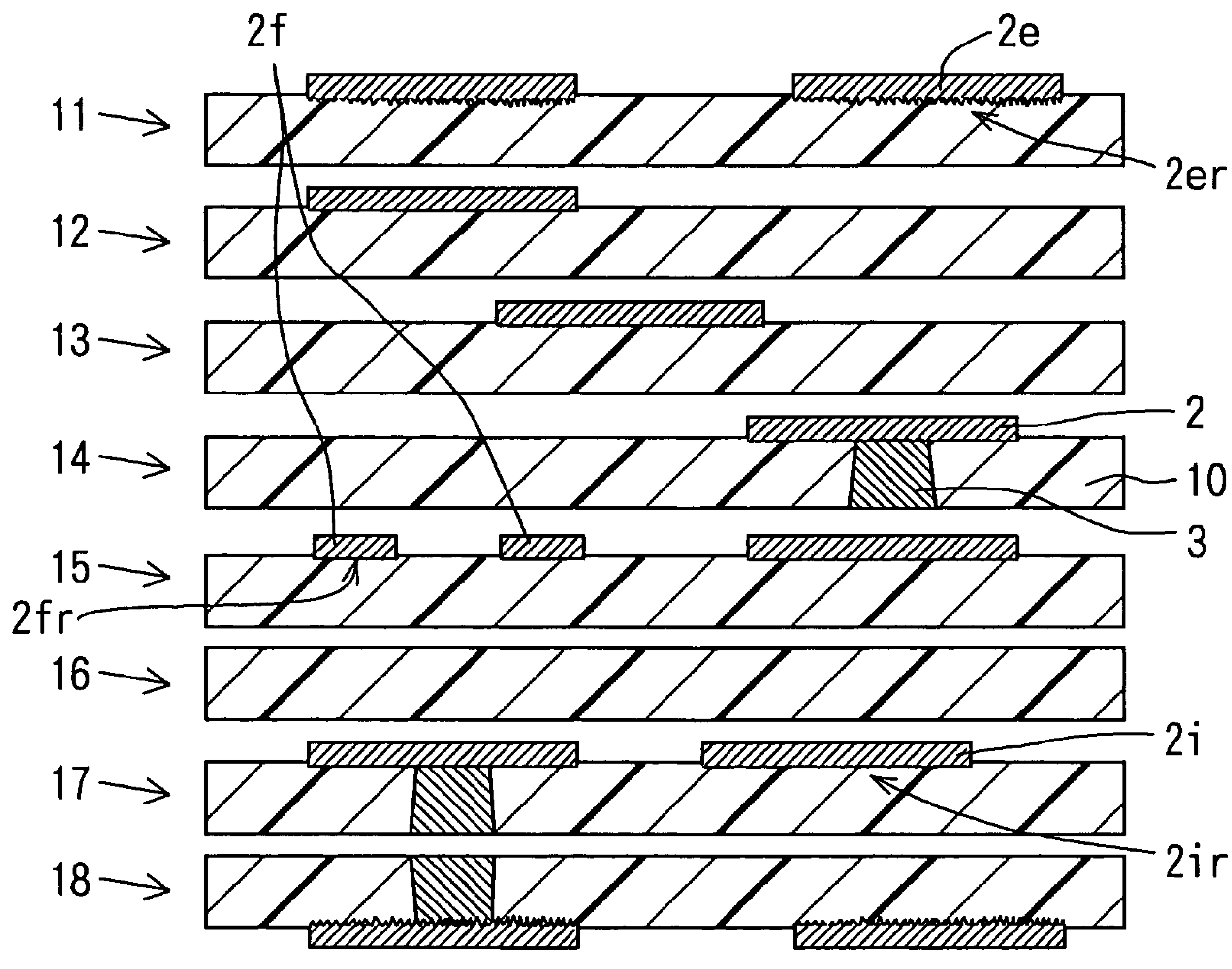
FIG. 1B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2ir

FIG. 2

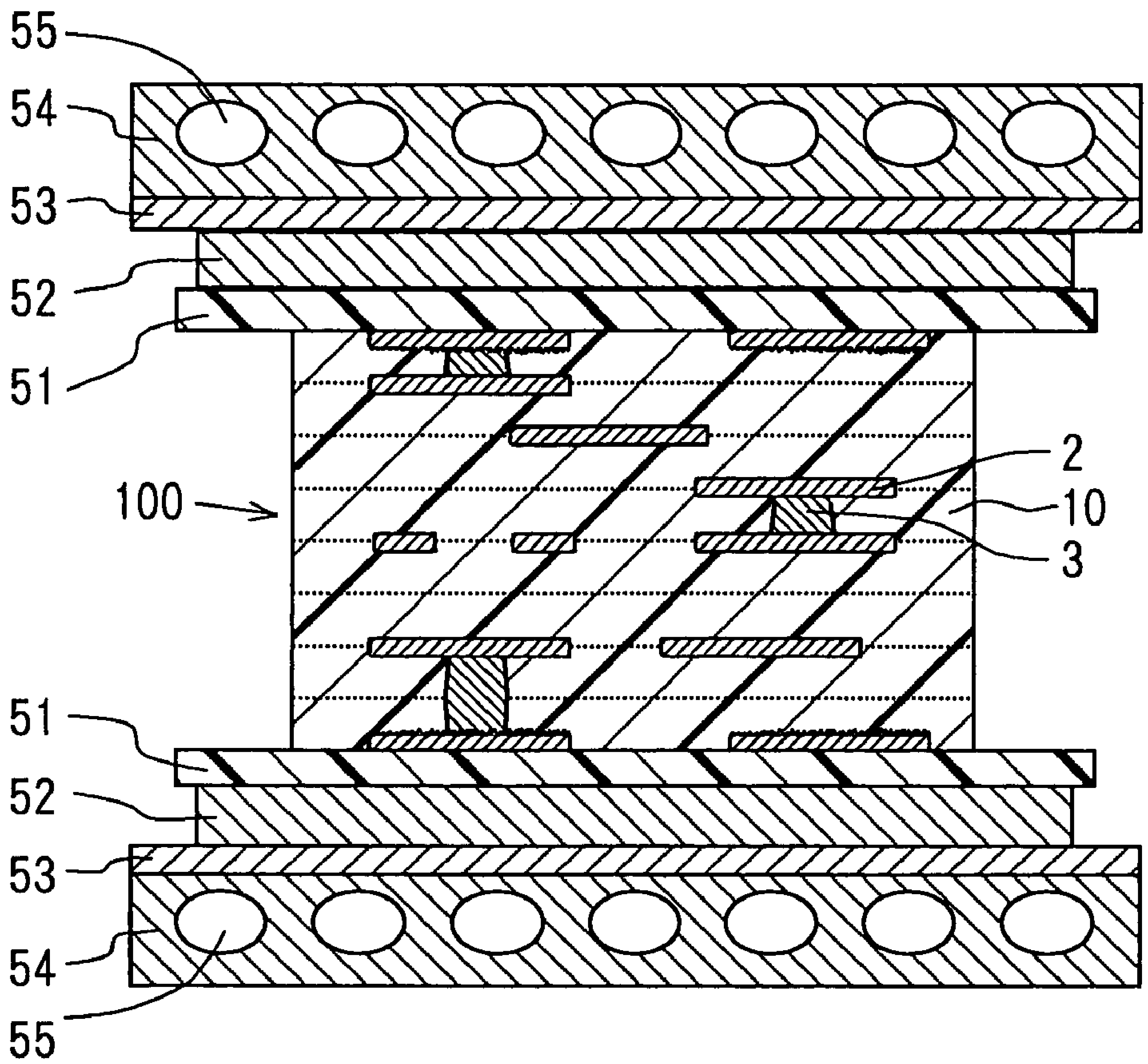
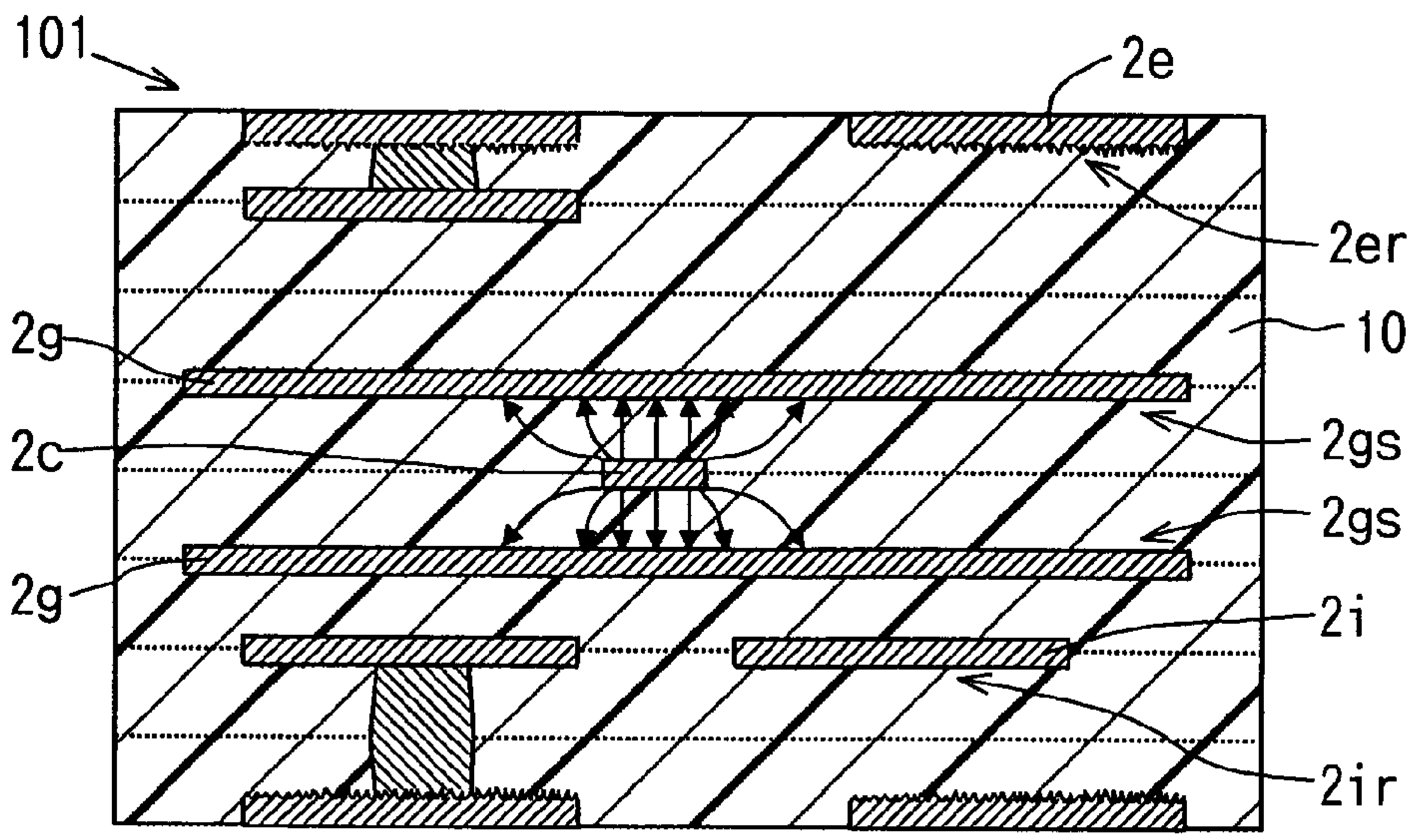


FIG. 3A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2e
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2g
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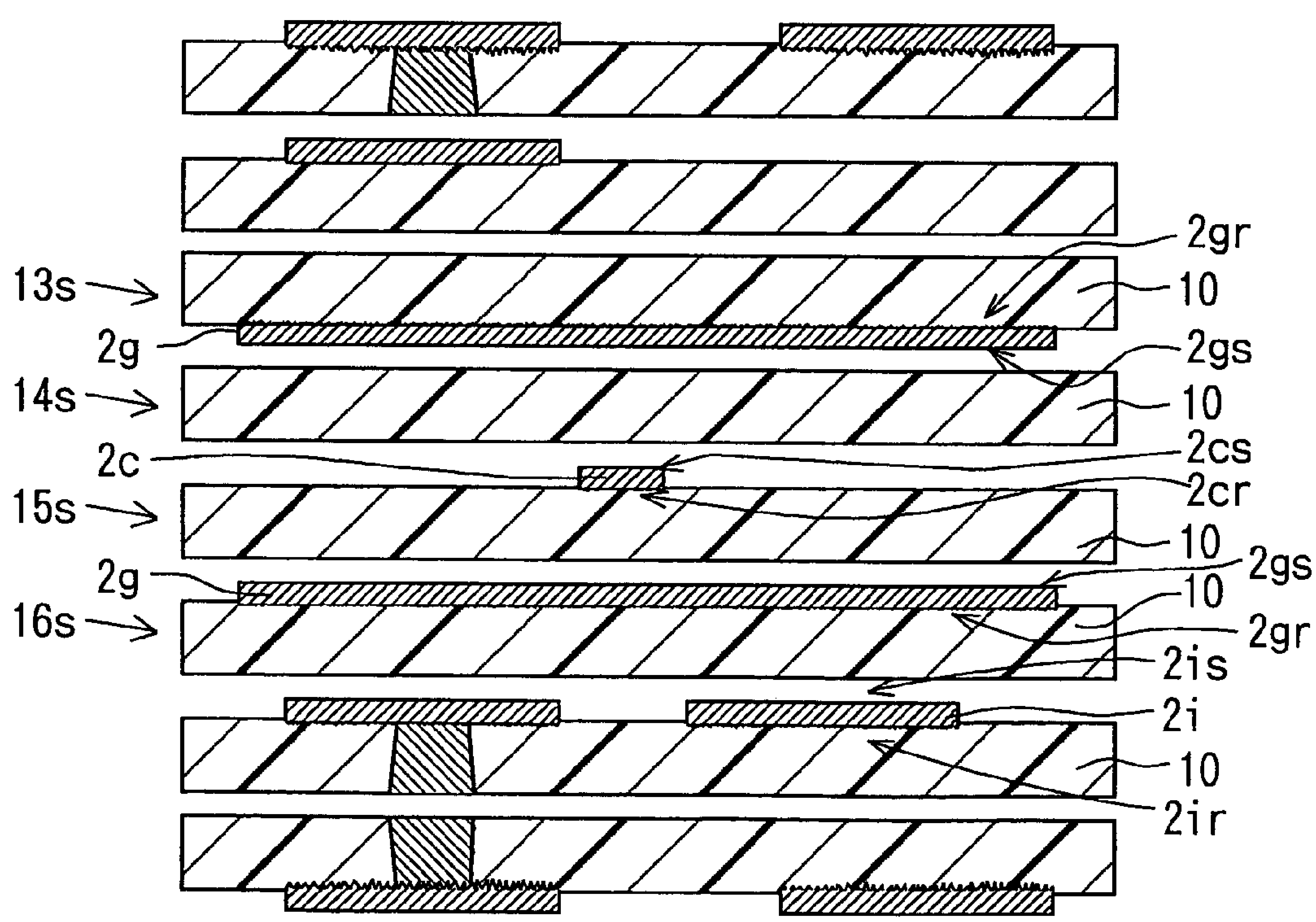
2ir

FIG. 3B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14s
10
2cs
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10
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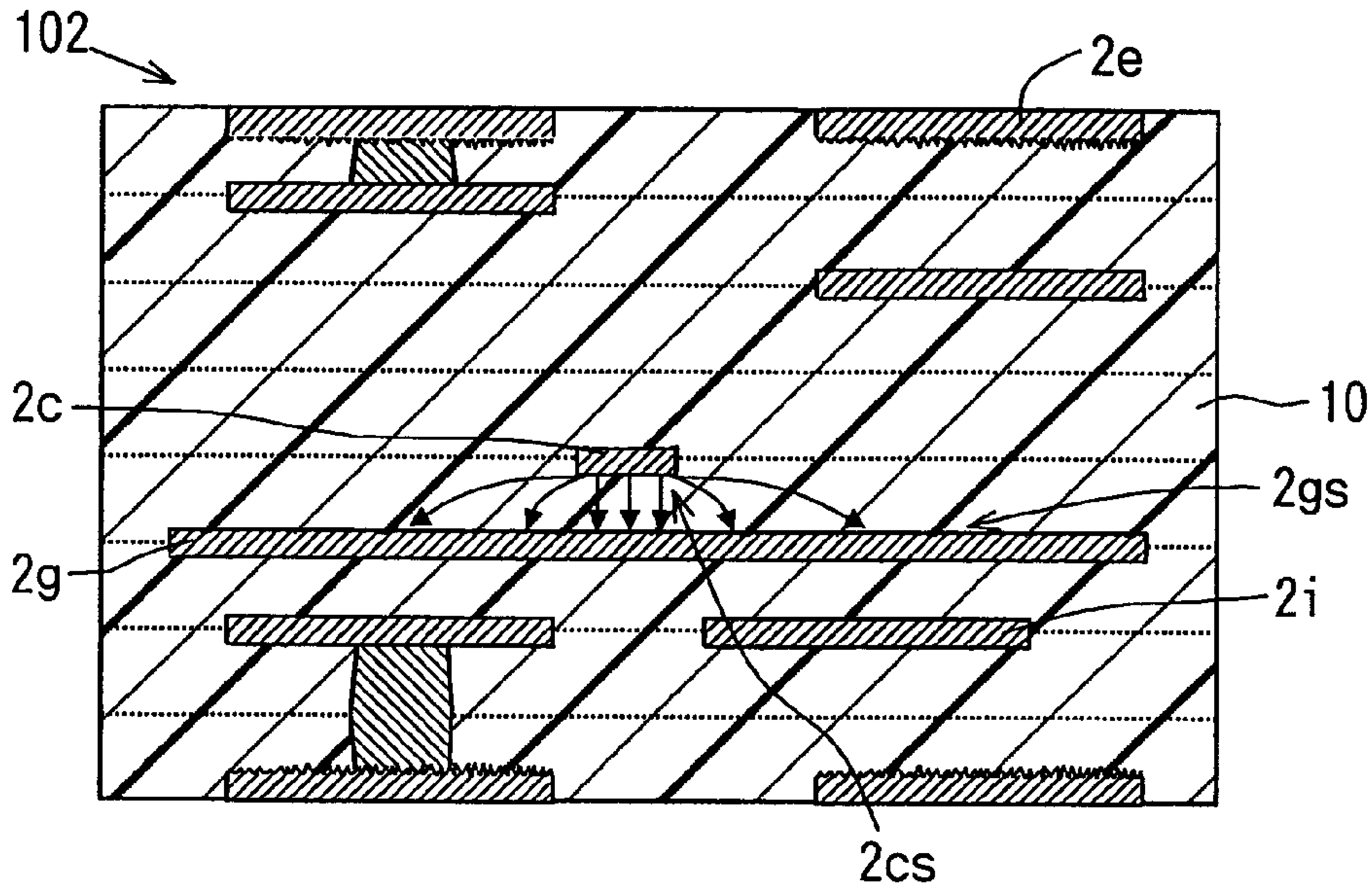
2gr
2is
2i
10
2ir

FIG. 4A


102
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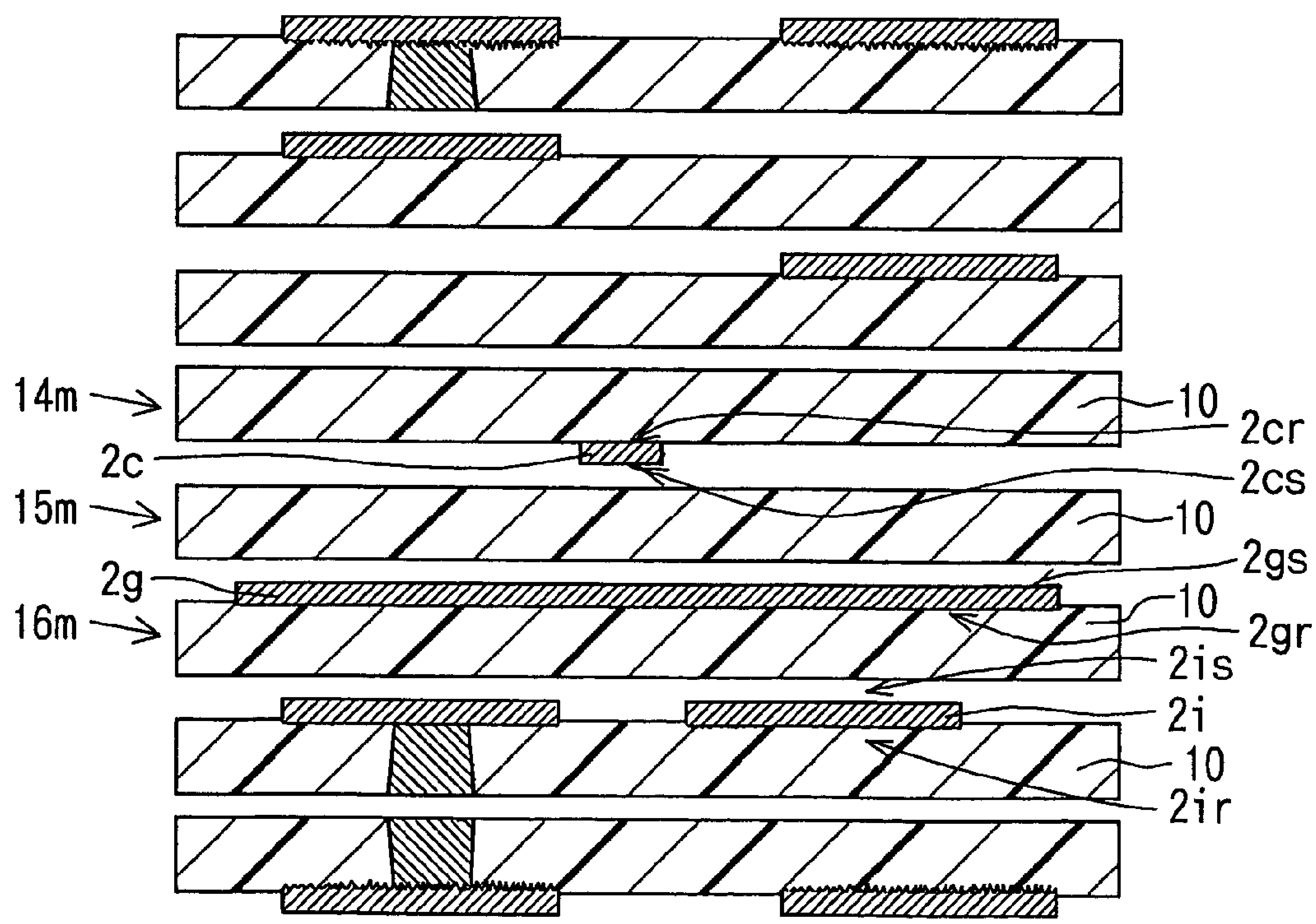
2i
2cs

FIG. 4B


14m
10
2cr
2c
2cs
15m
10
2gs
2g
10
16m
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2is
2i
10
2ir

MULTI-LAYER PRINTED CIRCUIT BOARD AND METHOD FOR MANUFACTURING THE SAME

CROSS REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Application No. 2003-101460 filed on Apr. 4, 2003, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a multi-layer printed circuit board and a method for manufacturing the same. The multi-layer printed circuit board includes an insulation layer and a wiring layer formed of a conductive pattern, which are laminated alternately. Specifically, the present invention relates to a multi-layer printed circuit board suitably used for a high frequency circuit and a method for manufacturing the same.

BACKGROUND OF THE INVENTION

A multi-layer printed circuit board used for a high frequency circuit is, for example, disclosed in Japanese Patent Application Publication No. H01-120095 (i.e., U.S. Pat. No. 4,931,354). The multi-layer printed circuit board includes multiple insulation layers made of ceramics and multiple wiring layers having conductivity, which are laminated and integrated together. A cavity is formed between an upper surface and/or a sidewall of an inner conductive wiring layer and the insulation layer disposed on the inner conductive wiring layer.

Since the multi-layer printed circuit board includes the cavity formed between the upper surface and/or the sidewall of the inner conductive wiring layer and the insulation layer disposed on the inner conductive wiring layer, the total dielectric constant of the multi-layer printed circuit board is reduced. Therefore, high frequency properties of the multi-layer printed circuit board such as a delay of propagation of a signal are improved.

However, not only the dielectric constant of the insulation layer but also the surface roughness of the wiring layer affect the high frequency properties of the signal. Thus, the factor for affecting the high frequency properties of the signal is provided by the dielectric constant of the insulation layer and the surface roughness of the wiring layer. As the surface of the wiring layer becomes rough, the surface resistance of the wiring layer becomes larger. Therefore, the properties of a high frequency alternating current flowing through the wiring layer are deteriorated. Specifically, as the frequency of the high frequency alternating current becomes higher, the high frequency alternating current flows nearer the surface of the wiring layer because of a skin effect. Thus, the surface roughness of the wiring layer affects the high frequency properties largely.

Further, another multi-layer printed circuit board is, for example, disclosed in Japanese Patent Application Publication No. 2000-38464 (i.e., U.S. Pat. No. 6,228,467). The multi-layer printed circuit board includes an insulation layer and a wiring layer formed of a conductive pattern, which are laminated together. The multi-layer printed circuit board is manufactured as follows. Multiple conductive pattern films are prepared. The conductive pattern film includes a resin film made of thermoplastic resin and a conductive pattern made of copper foil. The conductive pattern is disposed on

the resin film. These conductive pattern films are laminated in a predetermined order, and then, the laminated conductive pattern films are heated and pressurized at a predetermined temperature under a predetermined pressure. Thus, the resin films of the neighboring conductive pattern films are adhered and integrated together, so that the multi-layer printed circuit board is manufactured.

Since all multiple laminated conductive pattern films are adhered at the same time by heating and pressurizing, a process for forming the multi-layer printed circuit board is shortened. Thus, the manufacturing cost becomes small.

However, when the surface roughness of the conductive pattern becomes small in order to improve the high frequency properties, the conductive pattern exposed on the surface of the multi-layer printed circuit board easily peels off.

SUMMARY OF THE INVENTION

In view of the above-described problem, it is an object of the present invention to provide a multi-layer printed circuit board and a method for manufacturing the same. The manufacturing cost of the multi-layer printed circuit board is small, and a conductive pattern of the multi-layer printed circuit board is prevented from peeling off. Further, the multi-layer printed circuit board is suitable for providing a high frequency circuit.

The multi-layer printed circuit board according to a preferred embodiment of the present invention includes an insulation substrate made of insulation material, a surface conductive pattern and an inner conductive pattern. The surface conductive pattern is disposed on the surface of the insulation substrate. The inner conductive pattern is embedded in the insulation substrate. The surface conductive pattern has a large surface roughness on the insulation substrate side. The surface roughness of the surface conductive pattern is larger than that of the inner conductive pattern.

In the multi-layer printed circuit board, the surface roughness of the surface conductive pattern on the insulation substrate side is set to be large in order to increase adhesive strength so that the surface conductive pattern exposed on the surface of the multi-layer printed circuit board does not peel off easily. On the other hand, although the surface roughness of the inner conductive pattern is smaller than that of the surface conductive pattern on the insulation substrate side, an external force for peeling off the inner conductive pattern does not apply to the inner conductive pattern. That is because the inner conductive pattern is embedded in the multi-layer printed circuit board. Thus, the multi-layer printed circuit board has the surface and inner conductive patterns prevented from peeling off.

Preferably, the inner conductive pattern includes a high frequency conductive pattern for providing a high frequency circuit. In this case, the surface roughness of the inner conductive pattern is set to be smaller than that of the surface conductive pattern on the insulation substrate side. Therefore, the surface resistance of the inner conductive pattern is smaller than that of the surface conductive pattern, so that the inner conductive pattern has excellent properties as a conductive wire for flowing a high frequency alternating current, which is superior to the surface conductive pattern. Accordingly, the multi-layer printed circuit board having the inner conductive pattern used as the high frequency conductive pattern is suitable for providing the high frequency circuit.

Preferably, the high frequency conductive pattern is a strip line having a strip-shaped conductive pattern and a pair of wide grounding conductive patterns. The strip-shaped conductive pattern is sandwiched by the wide grounding conductive patterns through the insulation material of the insulation substrate in the thickness direction of the insulation substrate. More preferably, each grounding conductive pattern has a surface roughness disposed on the facing surface of the grounding conductive pattern facing each other and another surface roughness disposed on the opposite side, respectively. The surface roughness on the facing surface side is smaller than the other surface roughness on the opposite side. In this case, a high frequency signal is transmitted between the strip-shaped conductive pattern and the grounding conductive patterns disposed on both sides of the strip-shaped conductive pattern. Therefore, the high frequency alternating current having high frequency flows near the surface of each of the strip-shaped conductive pattern and the grounding conductive patterns. Accordingly, the multi-layer printed circuit board having the inner conductive pattern provided by the strip line is suitable for providing the high frequency circuit. Specifically, since the strip line includes the grounding conductive patterns having a small surface roughness on the facing surface side, the strip line has a small surface resistance against the high frequency alternating current compared with a strip line with a grounding conductive pattern having a normal surface roughness.

Preferably, the high frequency conductive pattern is a micro strip line having a strip-shaped conductive pattern and a wide grounding conductive pattern. The strip-shaped conductive pattern is disposed on the wide grounding conductive pattern through the insulation material of the insulation substrate in the thickness direction of the insulation substrate. More preferably, each of the grounding conductive pattern and the strip-shaped conductive pattern has a surface roughness disposed on the facing surface of the grounding conductive pattern or the strip-shaped conductive pattern facing each other and another surface roughness disposed on the opposite side, respectively. The surface roughness on the facing surface side is smaller than the other surface roughness on the opposite side. In this case, a high frequency signal is transmitted between the strip-shaped conductive pattern and the grounding conductive pattern in the micro strip line similar to the above strip line. Therefore, the high frequency alternating current having high frequency flows near the surface of each of the strip-shaped conductive pattern and the grounding conductive pattern. Accordingly, the multi-layer printed circuit board having the inner conductive pattern provided by the micro strip line is suitable for providing the high frequency circuit. Specifically, since the micro strip line includes the grounding conductive pattern and the strip-shaped conductive pattern having a small surface roughness on the facing surface side, respectively, the micro strip line has a small surface resistance against the high frequency alternating current compared with a micro strip line with a grounding conductive pattern and a strip-shaped conductive pattern having a normal surface roughness, respectively.

The method for manufacturing a multi-layer printed circuit board according to a preferred embodiment of the present invention includes the steps of: preparing a strip-shaped conductive pattern film by forming a strip-shaped conductive pattern made of metallic film on a resin film made of thermoplastic resin; preparing a pair of grounding conductive pattern films by forming a wide grounding conductive pattern made of metallic film on a resin film made of thermoplastic resin; preparing a spacer film including a resin film made of thermoplastic resin without any conductive pattern disposed on a part of the surface of the resin film, the part corresponding to the grounding conductive pattern; laminating the strip-shaped conductive pattern film, the spacer film and the grounding conductive pattern films in such a manner that a pair of grounding conductive pattern films is arranged to face the grounding conductive patterns of the ground conductive pattern films together so that each surface of the grounding conductive pattern film disposing the grounding conductive pattern faces inside, the spacer film is laminated on the surface of the strip-shaped conductive pattern film disposing the strip-shaped conductive pattern of the strip-shaped conductive pattern film, and the laminates of the strip-shaped conductive pattern film and the spacer film are inserted between a pair of the grounding conductive pattern films so that the grounding conductive pattern films are disposed on both sides of the strip-shaped conductive pattern film through the resin film; bonding each resin film together by heating and pressurizing the laminates of the strip-shaped conductive pattern film, the spacer film and the grounding conductive pattern films.

The method provides to manufacture the multi-layer printed circuit board having the conductive patterns disposed on the surface of the circuit board and/or disposed inside of the circuit board. The conductive patterns are prevented from peeling off. Further, when the inner conductive pattern of the multi-layer printed circuit board is used for the high frequency conductive pattern, the multi-layer printed circuit board is suitable for providing the high frequency circuit.

Further, another method for manufacturing a multi-layer printed circuit board according to a preferred embodiment of the present invention includes the steps of: preparing a strip-shaped conductive pattern film by forming a strip-shaped conductive pattern made of metallic film on a resin film made of thermoplastic resin; preparing a grounding conductive pattern film by forming a wide grounding conductive pattern made of metallic film on a resin film made of thermoplastic resin; preparing a spacer film including a resin film made of thermoplastic resin without any conductive pattern disposed on a part of the surface of the resin film, the part corresponding to the grounding conductive pattern; laminating the strip-shaped conductive pattern film, the spacer film and the grounding conductive pattern film in such a manner that the grounding conductive pattern film and the strip-shaped conductive pattern film are arranged to face the grounding conductive pattern of the ground conductive pattern film and the strip-shaped conductive pattern of the strip-shaped conductive pattern film together so that each surface of the grounding conductive pattern film disposing the grounding conductive pattern and the surface of the strip-shaped conductive pattern film disposing the strip-shaped conductive pattern faces inside, the spacer film is inserted between the strip-shaped conductive pattern film and the grounding conductive pattern film so that the grounding conductive pattern film is disposed on one side of the strip-shaped conductive pattern film through the resin film; bonding each resin film together by heating and pressurizing the laminates of the strip-shaped conductive pattern film, the spacer film and the grounding conductive pattern film.

The method provides to manufacture the multi-layer printed circuit board having the conductive patterns disposed on the surface of the circuit board and/or disposed inside of the circuit board. The conductive patterns are prevented from peeling off. Further, when the inner conductive pattern of the multi-layer printed circuit board is used for the high frequency conductive pattern, the multi-layer printed circuit board is suitable for providing the high frequency circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1**A is a schematic cross sectional view showing a multi-layer printed circuit board, and FIG. **1**B is a cross sectional view explaining a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board, according to a preferred embodiment of the present invention;

FIG. **2** is a schematic cross sectional view explaining a bonding process for heating and pressurizing in the manufacturing process of the multi-layer printed circuit board;

FIG. **3**A is a schematic cross sectional view showing a multi-layer printed circuit board having a high frequency conductive pattern provided by a strip line, and FIG. **3**B is a cross sectional view explaining a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board, according to another preferred embodiment of the present invention; and

FIG. **4**A is a schematic cross sectional view showing a multi-layer printed circuit board having a high frequency conductive pattern provided by a micro strip line, and FIG. **4**B is a cross sectional view explaining a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board, according to further another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A multi-layer printed circuit board **100** according to a preferred embodiment of the present invention is shown in FIG. **1**A. FIG. **1**B explains a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board **100**.

The multi-layer printed circuit board **100** shown in FIG. **1**A includes an insulation substrate **1** made of thermoplastic resin and a wiring layer for providing a conductive pattern **2** made of metallic film. Specifically, the multi-layer printed circuit board **100** includes, for example, eight conductive pattern films **11**–**18** laminated and bonded together, as shown in FIG. **1**B. Each conductive pattern film **11**–**18** includes a resin film **10** made of thermoplastic resin and the conductive pattern **2**. The conductive pattern **2** made of metallic film has a predetermined pattern, and is disposed on the resin film **10**. The thermoplastic resin for providing the insulation substrate **1** shown in FIG. **1**A and the resin film **10** composing the insulation film **1** shown in FIG. **1**B are, for example, a liquid crystal polymer (i.e., LCP) and the like. The metallic film for providing the conductive pattern **2** is a copper foil and the like. Here, a conductive material member **3** is filled in a hole disposed in the insulation substrate **1**, as shown in FIG. **1**A. The conductive material member **3** connects between the conductive patterns **2** disposed on different layers, respectively.

As shown in FIG. **1**B, the multi-layer printed circuit board **100** includes a surface conductive pattern **2*e*** and an inner conductive pattern **2*i***. The surface conductive pattern **2*e*** is exposed on the surface of the multi-layer printed circuit board, and has a surface roughness **2*er*** on the insulation substrate **1** side. The inner conductive pattern **2*i*** is embedded in the multi-layer printed circuit board **100**, and has a surface roughness **2*ir***. The surface roughness **2*er*** of the surface conductive pattern **2*e*** is larger than the surface roughness **2*ir*** of the inner conductive pattern **2*i***. Thus, the surface roughness **2*er*** of the surface conductive pattern **2*e*** on the insulation substrate **1** side is set to be larger in order to increase the adhesion strength. Therefore, the surface conductive pattern **2*e*** is prevented from peeling off although the surface conductive pattern **2*e*** is exposed on the surface of the multi-layer printed circuit board **100**, as shown in FIG. **1**A. On the other hand, the surface roughness **2*ir*** of the inner conductive pattern **2*i*** is smaller than the surface roughness **2*er*** of the surface conductive pattern **2*e*** on the insulation substrate **1** side. However, since the inner conductive pattern **2*i*** is embedded in the insulation substrate **1** of the multi-layer printed circuit board **100**, an outside force for peeling off the inner conductive pattern **2*i*** does not apply to the inner conductive pattern **2*i***. Accordingly, the multi-layer printed circuit board **100** includes conductive patterns **2** disposed on the surface of the multi-layer printed circuit board **100** and disposed in the circuit board **100**, the conductive patterns **2** being prevented from peeling off.

In the multi-layer printed circuit board **100** shown in FIG. **1**A, the inner conductive pattern **2*f*** is a high frequency conductive pattern **2*f*** for providing a high frequency circuit. On the other hand, other conductive patterns **2*i*** are normal frequency conductive patterns for transmitting a low frequency signal having a low frequency lower than that of the high frequency conductive pattern **2*f***. The surface roughness **2*fr***, **2*ir*** of the inner conductive pattern **2*f***, **2*i*** is set to be smaller than the surface roughness **2*er*** of the surface conductive pattern **2*e*** on the insulation substrate **1** side. Therefore, the surface resistance of the inner conductive pattern **2*f***, **2*i*** is smaller than that of the surface conductive pattern **2*e***, so that the inner conductive pattern **2*f***, **2*i*** as a conductive wiring for flowing the high frequency alternating current is superior to the surface conductive pattern **2*e***. Accordingly, the multi-layer printed circuit board **100** shown in FIG. **1**A includes the inner conductive pattern **2*f*** having the small surface resistance for providing the high frequency conductive pattern **2*f***, so that the multi-layer printed circuit board **100** is suitable for providing the high frequency circuit.

The multi-layer printed circuit board **100** shown in FIG. **1**A is manufactured as follows.

At first, the conductive pattern **2** having a predetermined pattern is formed on the resin film **10** made of thermoplastic resin so that each conductive pattern film **11**–**18** is prepared. The conductive pattern **2** is made of a metallic film. Next, a hole having a bottom is formed in the resin film **10** by a laser beam drilling method. The bottom of the hole is the conductive pattern **2**. A conductive paste is filled in the hole having the bottom. The conductive paste filled in the hole having the bottom is sintered so that the conductive material member **3** is formed, as shown in FIG. **1**A. Thus, the conductive pattern films **11**–**18** are prepared.

Next, the conductive pattern films **11**–**18** prepared in the above process are laminated such that the conductive pattern films **11**–**18** have a certain arrangement and a certain orientation, as shown in FIG. **1**B.

Next, the laminated conductive pattern films **11**–**18** shown in FIG. **1**B are mounted between a pair of hot press plates **54** through an adhesion protection film **51**, a buffer **52** and a metal plate **53**, as shown in FIG. **2**. A heater **55** is embedded in the hot press plates **54**. Thus, the laminated conductive pattern films **11**–**18** are heated and pressurized so that the conductive pattern films **11**–**18** are bonded together at the same time. Further, the conductive paste in the hole is sintered.

Here, the adhesion protection film **51** shown in FIG. **2** prevents the resin film **10** from adhering to other part disposed around the resin film **10** in case of heating and pressurizing. Further, the adhesion protection film **51** protects the resin film **10** and the conductive pattern **2** from being damaged. The adhesion protection film **51** is made of, for example, poly-imide film or the like. The buffer **52** works for pressurizing the laminated conductive pattern films **11–18** uniformly. The buffer **52** is made of, for example, fibrous metal, which is formed by cutting a metal such as stainless steel and the like. The metal plate **53** prevents the hot press plate **54** from being damaged. The metal plate **53** is made of, for example, stainless steel (i.e., SUS), titanium (i.e., Ti) or the like. Here, a laminating order of the buffer **52** and the metal plate **53** shown in FIG. **2** may be reversed.

Thus, the heated and pressurized laminated conductive pattern films **11–18** are retrieved from the hot press plate **54**, so that the multi-layer printed circuit board **100** shown in FIG. **1**A is completed.

In the above method for manufacturing the multi-layer printed circuit board **100**, since the laminated conductive pattern films **11–18** are bonded together at the same time, a process for forming the multi-layer printed circuit board **100** is shortened. Therefore, the manufacturing cost of the multi-layer printed circuit board **100** becomes small.

Other multi-layer printed circuit boards **101**, **102** according to the preferred embodiment of the present invention are shown in FIGS. **3**A, **3**B, **4**A and **4**B.

FIG. **3**A is a schematic cross sectional view showing the multi-layer printed circuit board **101**. FIG. **3**B explains a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board **101**.

As shown in FIG. **3**A, a strip line has a construction such that a pair of wide grounding conductive pattern **2*g*** is disposed on both sides of a strip-shaped conductive pattern **2*c*** through the insulation material of the insulation substrate **1** in a laminating direction. In the strip line, a high frequency signal is transmitted between the strip-shaped conductive pattern **2*c*** and the grounding conductive patterns **2*g*** disposed on both sides thereof. In FIG. **3**A, arrows show electric field generated by the high frequency signal transmitted in the strip line. A high frequency alternating current having a high frequency flows in accordance with the transmission of the high frequency signal near the surface of each of the stripe-shaped conductive pattern **2*c*** and the grounding conductive patterns **2*g***, which faces each other.

In the multi-layer printed circuit board **101** shown in FIG. **3**A, the strip line including the strip-shaped conductive pattern **2*c*** and the grounding conductive patterns **2*g*** is formed as the inner conductive pattern. As described above, the surface roughness **2*cr***, **2*gr*** of the inner conductive pattern **2*c***, **2*g*** is set to be smaller than the surface roughness **2*er*** of the surface conductive pattern **2*e*** on the insulation substrate **1** side. Therefore, the strip-shaped conductive pattern **2*c*** and the grounding conductive patterns **2*g*** as the inner conductive pattern **2** have the surface resistance, which is smaller than that of the surface conductive pattern **2*e***. Accordingly, the multi-layer printed circuit board **101** having the strip line provided by the inner conductive pattern **2*c***, **2*g*** shown in FIG. **3**A is suitable for providing the high frequency circuit.

The strip line of the multi-layer printed circuit board **101** is manufactured as follows.

The conductive pattern **2*c*** having a strip shape made of metallic film is formed on the resin film **10** made of thermoplastic resin so that the strip-shaped conductive pattern film **15*s*** is prepared, as shown in FIG. **3**B. The wide grounding conductive pattern **2*g*** made of metallic film is formed on the resin film **10** made of thermoplastic resin so that the grounding conductive pattern film **13*s***, **16*s*** is prepared, as shown in FIG. **3**B. The spacer film **14*s*** is prepared such that the spacer film **14*s*** is formed of the resin film **10** made of thermoplastic resin without any conductive pattern disposed on a part of the surface of the resin film **10**, the part corresponding to the grounding conductive pattern **2*g*** (i.e., the spacer film **14*s*** has no conductive pattern disposed on the part corresponding to the grounding conductive pattern **2*g***).

Next, as shown in FIG. **3**B, a pair of the grounding conductive pattern films **13*s***, **16*s*** is arranged to face the grounding conductive patterns **2*g*** of the ground conductive pattern films **13*s***, **16*s*** together so that each surface of the grounding conductive pattern film **13*s***, **16*s*** disposing the grounding conductive pattern **2*g*** faces inside. Further, the spacer film **14*s*** is laminated on the surface of the strip-shaped conductive pattern film **15*s*** disposing the strip-shaped conductive pattern **2*c*** of the strip-shaped conductive pattern film **15*s***. Then, the laminates of the strip-shaped conductive pattern film **15*s*** and the spacer film **14*s*** are inserted between a pair of the grounding conductive pattern films **13*s***, **16*s*** so that the grounding conductive patterns **2*g*** are disposed on both sides of the strip-shaped conductive pattern **2*c*** through the resin film **10**.

The laminates of the strip-shaped conductive pattern film **15*s***, the spacer film **14*s*** and the grounding conductive pattern films **13*s***, **16*s*** shown in FIG. **3**B are heated and pressurized by the hot press plate so that each resin film **10** is bonded together. Thus, the multi-layer printed circuit board **101** having the strip line shown in FIG. **3**A is completed.

The conductive pattern **2*i*** as a constituent element of the multi-layer printed circuit board has the surface roughness **2*ir*** on the resin film **10** side, the surface roughness **2*ir*** being set to be larger than the surface roughness **2** is on the opposite side of the resin film **10** in general in order to secure the adhesion strength between the resin film **10** and the conductive pattern **2*i***. Thus, the strip line shown in FIG. **3**A is provided by a pair of grounding conductive patterns **2*g*** in such a manner that one surface of each grounding conductive pattern **2*g***, which is disposed on the small surface roughness **2*gs*** side, faces each other. Therefore, the strip line shown in FIG. **3**A has the small surface resistance compared with other strip lines having other laminating arrangements. Accordingly, the multi-layer printed circuit board **101** shown in FIG. **3**A is particularly suitable for providing the high frequency circuit.

FIG. **4**A shows further another multi-layer printed circuit board **102** having a micro strip line provided by the high frequency conductive patterns. FIG. **4**A is a schematic cross sectional view showing the multi-layer printed circuit board **102**. FIG. **4**B explains a laminating state of each constituent element in process of manufacturing the multi-layer printed circuit board **102**.

As shown in FIG. **4**A, the micro strip line has a construction such that the wide grounding conductive pattern **2*g*** is disposed on one side of the strip-shaped conductive pattern **2*c*** through the insulation material of the insulation substrate **1** in the laminating direction. In the micro strip line, a high frequency signal is transmitted between the strip-shaped conductive pattern **2*c*** and the grounding conductive pattern **2*g***, which is similar to the strip line in the multi-layer printed circuit board **101**. In FIG. **4**A, arrows show electric field generated by the high frequency signal transmitted in the micro strip line. A high frequency alternating current having a high frequency flows in accordance with the transmission of the high frequency signal near the surface of each of the stripe-shaped conductive pattern **2***c* and the grounding conductive pattern **2***g*, which faces each other.

In the multi-layer printed circuit board **102** shown in FIG. **4**A, the micro strip line including the strip-shaped conductive pattern **2***c* and the grounding conductive pattern **2***g* is formed as the inner conductive pattern **2**. As described above, the surface roughness **2***ir* of the inner conductive pattern **2***i* on the resin film **10** side is set to be smaller than the surface roughness **2***er* of the surface conductive pattern **2***e* on the insulation substrate **1** side. Therefore, the surface resistance of the inner conductive pattern **2***i* is small. Accordingly, the multi-layer printed circuit board **102** having the micro strip line provided by the inner conductive pattern **2***i* shown in FIG. **4**A is suitable for providing the high frequency circuit.

The micro strip line of the multi-layer printed circuit board **102** is manufactured as follows.

Similar to the method for manufacturing the strip line of the multi-layer printed circuit board **101** shown in FIG. **3**B, at first, the strip-shaped conductive pattern film **14***m*, the spacer film **15***m* and the grounding conductive pattern film **16***m* are prepared.

Then, the strip-shaped conductive pattern film **14***m* and the grounding conductive pattern film **16***m* are arranged to face the grounding conductive pattern **2***g* of the ground conductive pattern film **16***m* and the strip-shaped conductive pattern **2***c* of the strip-shaped conductive pattern film **14***m* each other so that each surface of the grounding conductive pattern film **16***m* disposing the grounding conductive pattern **2***g* and the strip-shaped conductive pattern film **14***m* disposing the strip-shaped conductive pattern **2***c* faces inside. Further, the spacer film **14***s* is inserted between the strip-shaped conductive pattern film **14***m* and the grounding conductive pattern film **16***m* so that the grounding conductive pattern **2***g* is disposed on one side of the strip-shaped conductive pattern **2***c* through the resin film **10**.

Then, the laminates of the strip-shaped conductive pattern film **14***m*, the spacer film **15***m* and the grounding conductive pattern film **16***m* are heated and pressurized by the hot press plate so that each resin film **10** is bonded together. Thus, the multi-layer printed circuit board **102** having the micro strip line shown in FIG. **4**A is completed.

The conductive pattern **2***i* as a constituent element of the multi-layer printed circuit board **102** has the surface roughness **2***ir* on the resin film **10** side, the surface roughness **2***ir* being set to be larger than the surface roughness **2***is* on the opposite side of the resin film **10** in general in order to secure the adhesion strength between the resin film **10** and the conductive pattern **2***i*. Thus, the micro strip line shown in FIG. **4**A is provided by the grounding conductive pattern **2***g* and the strip-shaped conductive pattern **2***c* in such a manner that one surface of the grounding conductive pattern **2***g*, which is disposed on the small surface roughness **2***gs* side, faces one surface of the strip-shaped conductive pattern **2***c*, which is disposed on the small surface roughness **2***cs* side. Therefore, the micro strip line shown in FIG. **4**A has the small surface resistance compared with other micro strip lines having other laminating arrangements. Accordingly, the multi-layer printed circuit board **102** shown in FIG. **4**A is particularly suitable for providing the high frequency circuit.

Thus, the above multi-layer printed circuit boards **100**–**102** are manufactured at a low cost, and the conductive pattern in them **100**–**102** are prevented from peeling off. Further, they **100**–**102** are suitable for providing the high frequency circuit.

What is claimed is:

1. A multi-layer printed circuit board comprising:

an insulation substrate;

a surface conductive pattern disposed on a surface of the insulation substrate; and

an inner conductive pattern embedded in the insulation substrate,

wherein the surface conductive pattern has a surface roughness on an insulation substrate side, the surface roughness of the surface conductive pattern being larger than that of the inner conductive pattern.

2. The multi-layer printed circuit board according to claim **1**,

wherein the inner conductive pattern includes a high frequency conductive pattern for providing a high frequency circuit.

3. The multi-layer printed circuit board according to claim **2**,

wherein the high frequency conductive pattern is a strip line,

wherein the strip line includes a strip-shaped conductive pattern and a pair of wide grounding conductive patterns, and

wherein the strip-shaped conductive pattern is sandwiched between the wide grounding conductive patterns through the insulation substrate in a thickness direction of the insulation substrate.

4. The multi-layer printed circuit board according to claim **3**,

wherein each grounding conductive pattern has a surface roughness on one surface facing each other and another surface roughness on another surface opposite to the one surface, and

wherein the surface roughness on the one surface facing each other is smaller than the other surface roughness on the other surface opposite to the one surface.

5. The multi-layer printed circuit board according to claim **2**,

wherein the high frequency conductive pattern is a micro strip line,

wherein the micro strip line includes a strip-shaped conductive pattern and a wide grounding conductive pattern, and

wherein the strip-shaped conductive pattern is disposed on the wide grounding conductive pattern through the insulation substrate in a thickness direction of the insulation substrate.

6. The multi-layer printed circuit board according to claim **5**,

wherein each of the grounding conductive pattern and the strip-shaped conductive pattern has a surface roughness on one surface facing each other and another surface roughness on another surface opposite to the one surface, respectively, and

wherein each surface roughness of the grounding conductive pattern and the strip-shaped conductive pattern on the one surface facing each other is smaller than the other surface roughness of the grounding conductive pattern or the strip-shaped conductive pattern on the other surface opposite to the one surface, respectively.

7. The multi-layer printed circuit board according to claim **1**, wherein the insulation substrate has a construction in such a manner that a plurality of thermoplastic resin films are integrally laminated,

wherein the inner conductive pattern and the surface conductive pattern are made of metallic film, and provide wiring layers, respectively, and

wherein the surface conductive pattern has one side exposed to an outside, the one side being opposite to the insulation substrate side.

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